Mission Requirements

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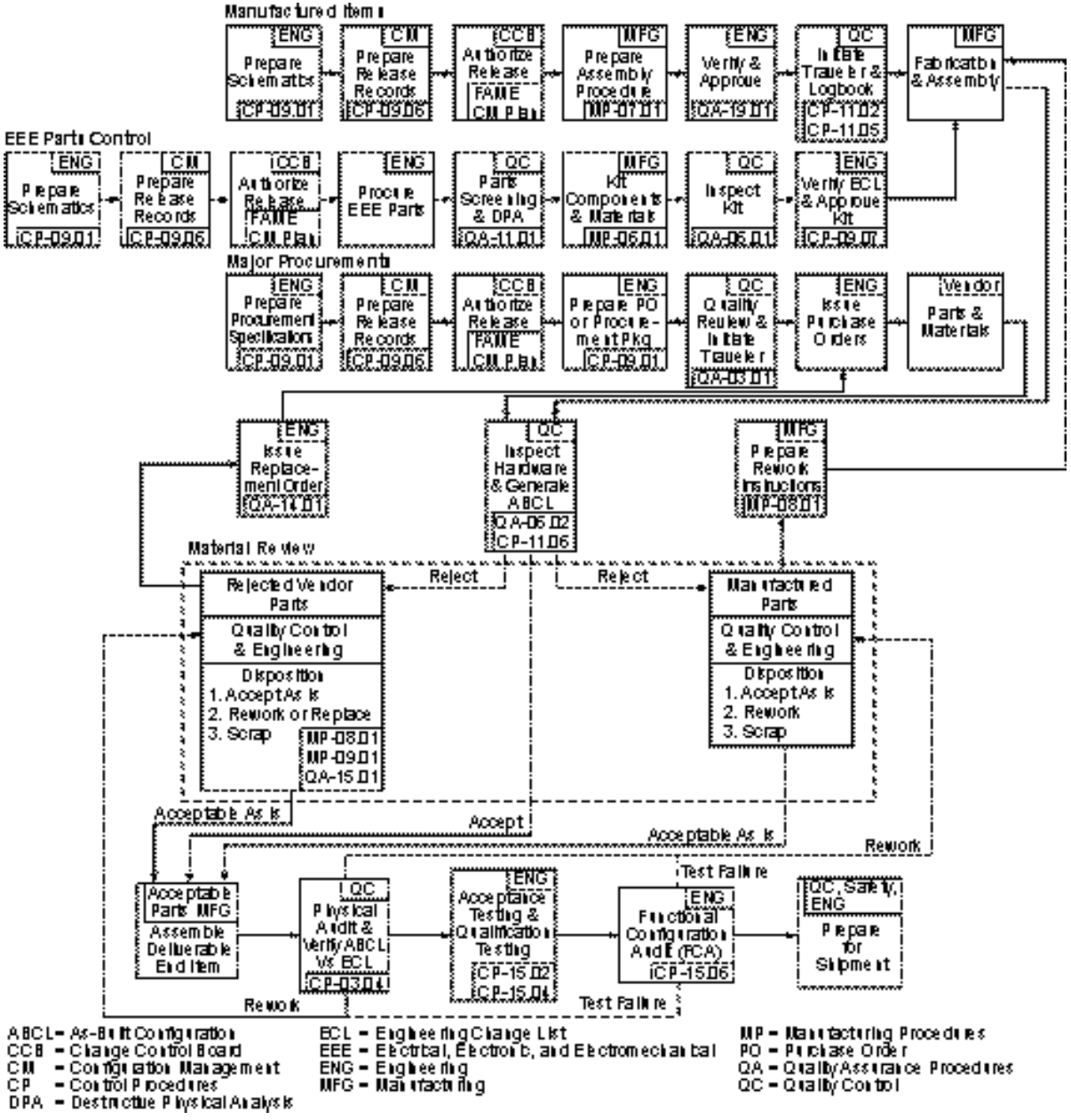
FAME Flight Assurance Requirements (1 of 8)

- Quality System
  - Quality Assurance Plan (QAP) Based On Guidelines of ANSI/ASQC Q9001-1994
  - Includes Workmanship, Personnel Training, Non-Conformance Control, Procurement Control, Metrology, Configuration Management, Contamination Control, and S/W QA
- Workmanship
  - Specified in Supplier-Approved Process Specifications
  - Printed Wiring Board (PWB) Coupons Tested by GSFC Prior to Assembly of Circuit Cards
  - Employ Guidelines of NASA, Commercial, or Military Standards
- Failure Reporting
  - Failure Review and Corrective Action System (FRACAS) Beginning at Acceptance Testing
    - Includes Discrepancy Reports for Hardware and Software
  - Failure Review Board (FRB) Chaired by the NRL Systems Engineer

QA Program Flow



FAME Flight Assurance Requirements (2 of 8)

- Reviews
  - System Requirements Review (SRR)
  - Preliminary Design Review (PDR) (End of Phase B)
  - Confirmation Review (CONR) (End of Phase B)
    - Briefing to NASA
  - Critical Design Review (CDR) (End of Phase C)
  - Pre-Environmental Review (PER) (Phase C/D)
    - Also Called Test Readiness Review (TRR)
  - Pre-Ship Review (PSR) (Phase C/D)
  - Flight Readiness Review (FRR) (Phase C/D)
- NASA Plans to Have Red Teams at Most of Our Reviews

FAME Flight Assurance Requirements (3 of 8)

- System Safety Program
  - Identify and Control Hazards to Personnel, Facilities, Support Equipment, and Flight System During All Stages of Development
  - Meet Requirements of EWRR 127-1
  - Procedures
    - Develop and Submit Ground Operations Procedures
    - Identify and Highlight Hazardous Procedures
    - Comply With Applicable Launch Site Safety Regulations
  - Safety Data Package
    - Submit at Each Phase C/D Review, Up to and Including PSR
    - Include Detailed Description of Payload Design, Hazard Analysis Method, and Other Applicable Safety Related Information
    - Include Hazardous/Toxic Materials and Associated MSDs
  - Launch Site Safety Plan – As Required by Launch Site

FAME Flight Assurance Requirements (4 of 8)

- **Design Assurance**
  - **Parts**
    - **EEE Parts Selected, Specified, Screened, and Qualified per GSFC 311-INST-001 Rev A, Quality Level 2 or Better**
    - **Develop and Maintain EEE Parts Identification List**
  - **Materials and Processes**
    - **Implement Materials and Processes Program at Beginning of Phase B**
    - **Proposed Materials and Processes Documented and Available at PDR**
    - **Maintain List of Items and Appropriate Usage Records**

FAME Flight Assurance Requirements (5 of 8)

- **Bonding/Grounding**
  - **Use MIL-B-5087 As a Guideline**
  - **All Metallic Hardware Electrically Grounded to Spacecraft**
    - **Metal to Metal Impedance of 2.5 Milliohms or Less (Box to Deck)**
    - **Metal to Composite Impedance of 10 Ohms or Less**
  - **Primary Power Returns Only Grounded at Spacecraft Single Point Ground**
    - **Primary Power Isolated From Secondary Power Returns by a Minimum of 1 Megohm**
    - **No Power Returned Through Spacecraft Structure**
  - **All MLI Metal Surfaces Grounded to Metallic Structure With a DC Resistance of 10 Ohms or Less**

FAME Flight Assurance Requirements (6 of 8)

- Reliability Analysis
  - Worst Case Analysis of All New Circuit Designs
  - FMEA for Interfaces [All Rather Than Just Between S/C and Instrument]
  - Fault Tree Analysis [by NASA Request]
  - Reliability Predictions
    - No Minimum Reliability Number Specified
    - System Designed to Operate for 5 Years in FAME Orbit

FAME Flight Assurance Requirements (7 of 8)

- Software
  - Code Produced Shall Be Structured, Verified to Minimize Errors, and Maintainable
  - All Software Under CM at Initial Capability Build
  - S/W Development Plan (SDP)
  - S/W Product Specification (SPS)
    - Includes the CSCI Requirements, I/O Interfaces, Design Description, and Source Code
  - S/W Test Plan (STP)
    - Includes Test Methodology for the CSCI and Any External Equipment/Simulations Necessary for Testing
  - Software IV&V May Be Required

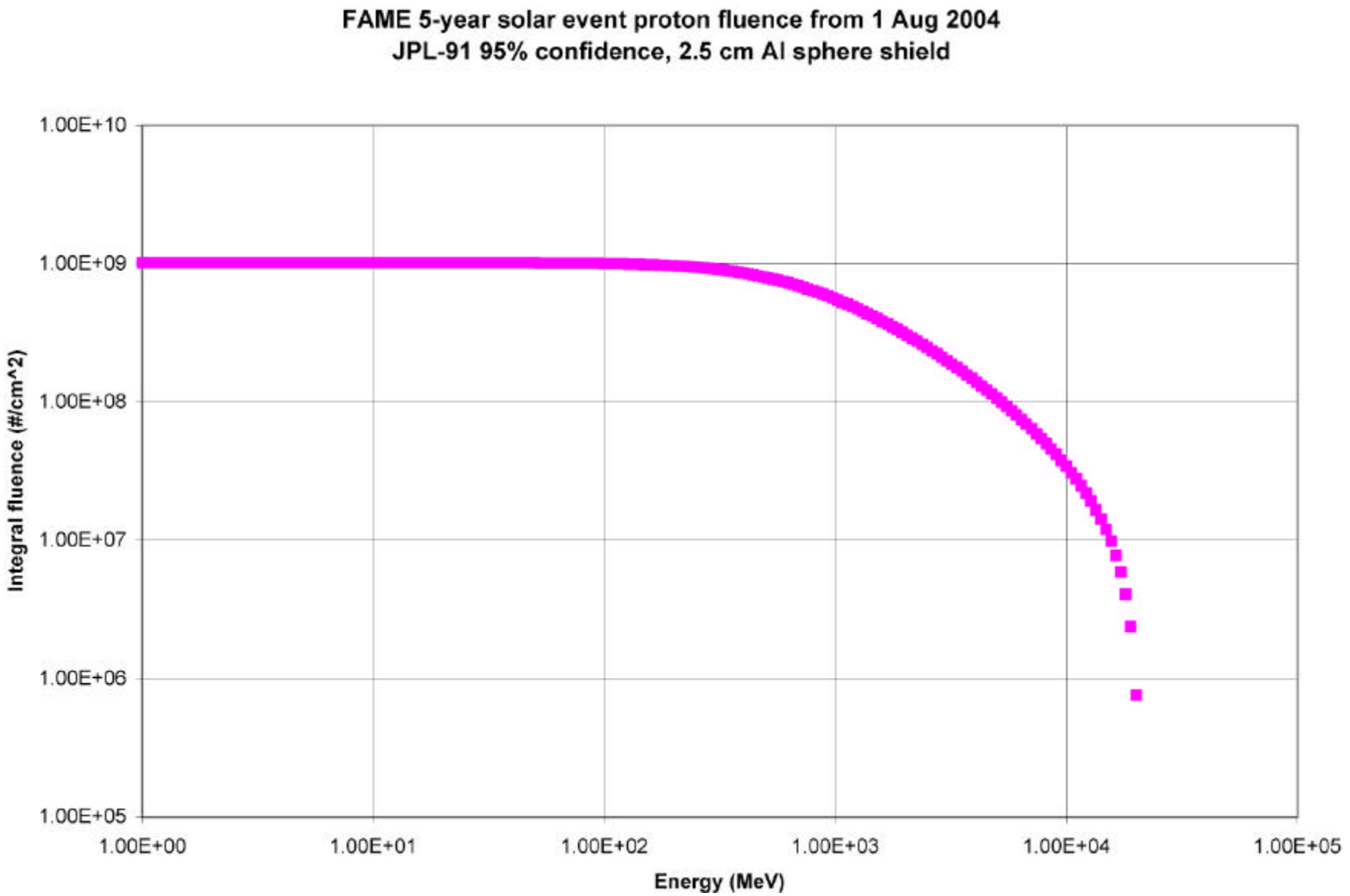
FAME Flight Assurance Requirements (8 of 8)

- **Verification Program**
  - **Ensure That the Spacecraft and Instrument Meet Specified Mission Requirements**
  - **Provide Verification Documentation, Including:**
    - **Verification Matrix**
    - **Environmental Test Matrix**
    - **Verification Procedures**

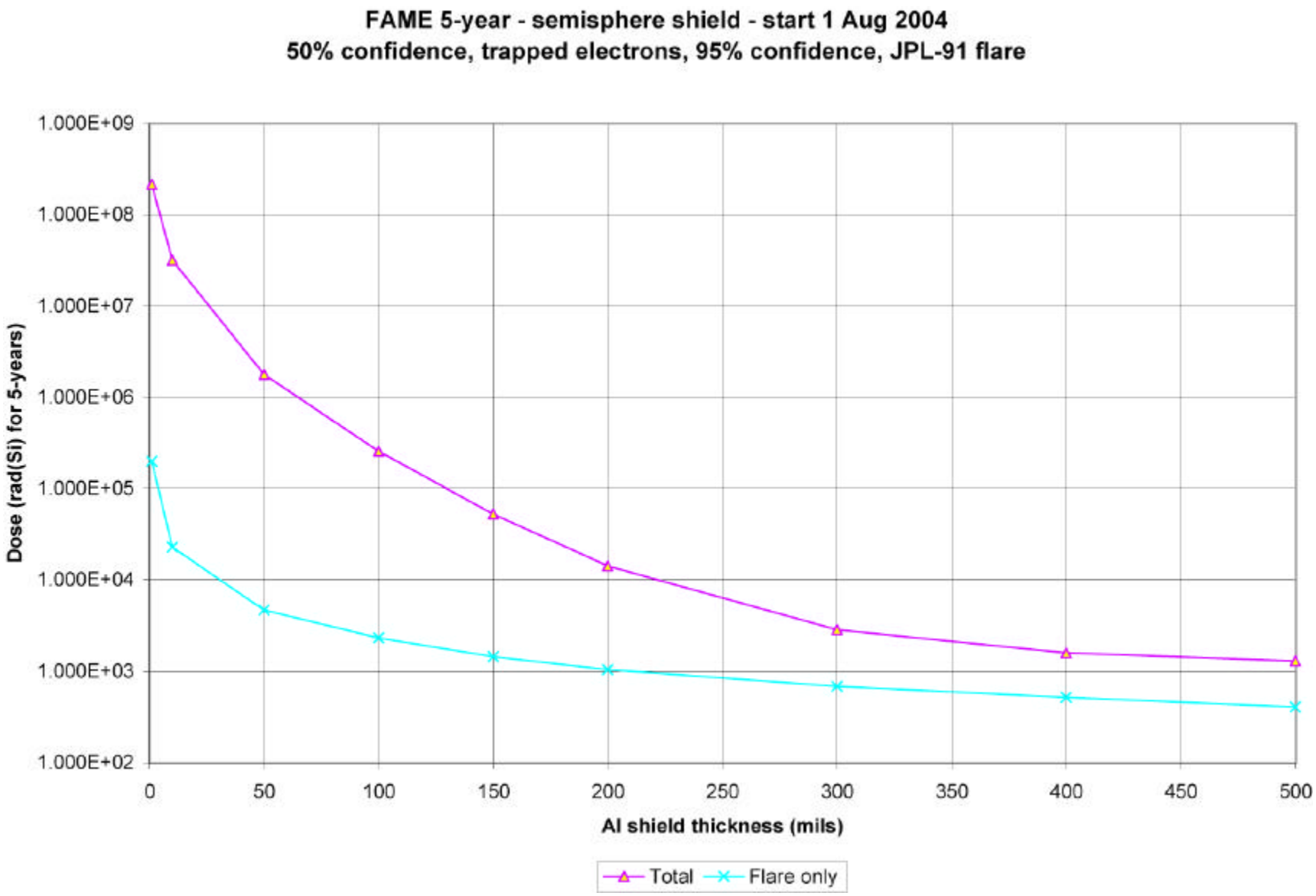
FAME Radiation Requirements

- Radiation Effects
- Total Dose (Dose/Depth Curve Provided)
  - Estimate Calculated With SPENVIS Code (Belgium/ESA)
  - Includes Improved Magnetospheric Models As Well As NASA AE8/AP8 Trapped Particle Models, JPL-91 Probabalistic Solar Event Model, NIST SHIELDOSE-2 Dose Depth Calculations, and the NRL CREME Cosmic Ray Model
  - 5 Year Period Beginning 1 August 2004
  - 50% Confidence for Trapped Electrons
  - 95% Confidence for Solar Events
- Single Event Upset
  - Single Event Upsets Allowed As Long As They Do Not Propogate to the System Level
- Single Event Latchup
  - No Destructive Latch-Ups Allowed

FAME 5-Year Solar Event Proton Fluence



FAME 5-Year


FAME 5-year - semisphere shield - start 1 Aug 2004
50% confidence, trapped electrons, 95% confidence, JPL-91 flare
Dose (rad(Si) for 5-years)
1.000E+09
1.000E+08
1.000E+07
1.000E+06
1.000E+05
1.000E+04
1.000E+03
1.000E+02
0
50
100
150
200
250
300
350
400
450
500
Al shield thickness (mils)
Total
Flare only

Launch Vehicle Requirements

- **Launch Vehicle Is a Delta 7425-10**
- **Vibration Analysis Will Determine Specific Vibration Environment for Each Subsystem**
- **Launch Environments (More Detail in Launch Vehicle Presentation):**
  - **Acoustics: 139.9 dB OASPL**
  - **Shock:** **100 Hz 40 g**
    1500 Hz 4100 g
    3000 Hz 4100 g
  - **Thermal:** **Acoustic Blanket Surface = 65°C to 70°C During Ascent**
    Fairing Separation = 1135 W/m^2
  - **Limit Loads:**

	Liftoff/Transonic	MECO
Lateral	±3 – 3.5 g	±0.1 g
Axial	+2.8/-0.2 g	7.6 ±0.6 g

  - **Sunusoidal Vibration:**

	Frequency	Maximum Flight Levels
Axial	5 – 6.2 Hz	1.27 cm (Double Amplitude)
	6.2 – 100 Hz	1.0 (Zero to Peak)
Lateral	5 – 100 Hz	0.7 g (Zero to Peak)

EMC/EMI Requirements

- Requirements TBD
- Driven by:
  - Spacecraft Receiver Interference
    - NRL RF Group to Specify
  - Instrument Sensitivities
    - Lockheed to Specify Frequencies and RF Power Levels
  - Range Requirements
    - Dictated by Range
- Subsystem/System Testing Must Verify That Conducted and Radiated Emissions Do Not Exceed Specified Levels [CE0/RE0 Requirements]
- Subsystem/System Testing Must Verify That They Are Not Susceptible to Conducted and Radiated Emissions [CS0/RS0 Requirements]

Documentation Deliverables

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Documentation Deliverables (1 of 3)

Document Name	Number	SRR	PDR	CDR	PER	PSR	FRR	Assignee	Status
Science Requirements Document	NCST-D-FM001	Final						K. Seidelmann	
Mission Requirements Document	NCST-D-FM002	Final						M. Johnson	Draft distributed at TIM, 7/12/00
FAME Error Budget								K. Johnston	
Systems Engineering Management Plan (SEMP)	NCST-D-FM004	Prel.	Final					M. Johnson	Outline
Product Assurance Plan	NCST-D-FM005	Prel.	Final					B. Mann	
SR&QA Plan	NCST-D-FM006	Prel.	Final					B. Mann	
Contamination Control Plan	NCST-D-FM007	Prel.	Rev.	Final				R. Mader	
Configuration Management Plan	NCST-D-FM008	Prel.	Final					M. Johnson	Draft
Software Management Plan	NCST-SDP-FM001	Final						J. Cleveland	Outline
Safety Documents									
Preliminary Safety Assessment	NCST-D-FM009	Prel.	Final					R. Mader	
System Safety Implementation Plan (SSIP)	NCST-D-FM010				Final			R. Mader	
Ground Operations Procedures (30 days before PER)					Final			P. Klein R. Contillo	
Safety Data Package						Final		R. Mader	
Launch Site Data Plan						Final		R. Mader	

Documentation Deliverables (2 of 3)

Document Name	Number	SRR	PDR	CDR	PER	PSR	FRR	Assignee	Status
Space Segment Documents									
Instrument									
Instrument Design Specification		Prel.	Final					S. Horner	
Instrument to S/C ICD	NSCT-ICD-FM001	Prel.	Final					M. Johnson	
Instrument subsystem and component specifications	LMMS document numbers		Prel.	Final				LMMS	
Spacecr aft									
S/C Design Specification	NCST-S-FM001	Prel.	Final					R. Mader, C. Garner	
S/C subsystem and component specifications	NCST-S-FM002 through NCST-S-FM00*n*		Prel.	Final				NRL	
System Integration and Test Plan	NCST-TP-FM001			Final				R. Mader, C. Garner	
Verification Matrix				Final				M. Ream	
Environmental Test Matrix				Final				M. Ream	
Verification Procedures				Final				NRL	
Integration and Test Procedures				Final				NRL	
Software Documents									
Software Requirements Document	NCST-SRS-FM001	Prel.	Final					J. Cleveland	

Documentation Deliverables (3 of 3)

Document Name	Number	SRR	PDR	CDR	PER	PSR	FRR	Assignee	Status
Launch Segment Documents									
S/C to L/V ICD	NCST-ICD-FM002		Prel.	Final				R. Mader	
Ground Segment Documents									
Ground Segment Description Document	NCST-D-FM016	Prel.	Final					P. Klein	
Space to Ground ICD	NCST-ICD-FM003		Prel.	Final				P. Klein	
Supporting Documents									
Failure Mode and Effects Analysis (FMEA)	NCST-D-FM011			Final				M. Johnson	
Preliminary EEE Parts List	NCST-D-FM012		Final					M. Johnson	
Preliminary Materials List	NCST-D-FM013		Final					R. Mader	
Orbital Debris Report (CDR +60 days)	NCST-D-FM014			Final				R. Mader	
Space Segment Reliability Analysis	NCST-D-FM015			Final				M. Johnson	
MO&DA Documents									
Data Analysis Requirements								R. Gaume	
Flight Operations Plan					Prel.	Final		P. Klein	
Software User Guides					Prel.	Final		J. Cleveland	
Final B/C/D Technical Report								M. Johnson	Launch +60 days
Final Phase E Technical Report								K. Johnston	End of Mission +60 days

Error Budget

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Error Budget Flowdown

Science Requirements

Observational Requirements

Error Budget

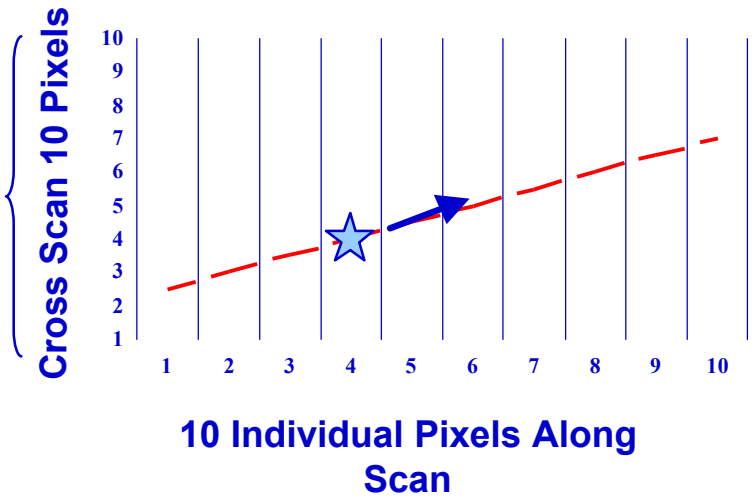
Observing Parameters

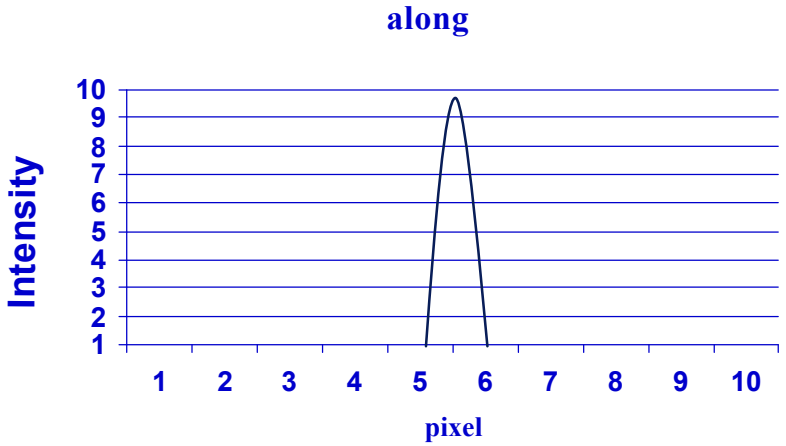
- **Instrument**
  - **Focal Length** — **15 m**
  - **Aperture** — **.6 m Along Scan**
    .13 m Cross Scan
  - **CCD** — **4096 x 2048**
    15 μm Pixel
    Quantum Efficiency 0.8
    Bandwidth 0.4 - 0.8 μm
    Operate in TDI Mode
  - **FOV** — **Two ~1° FOV Separated by 81° Along Scan**
- **Spacecraft**
  - **Rotation Rate** — **40 Minutes**
  - **Precession Rate** — **20 Days**
  - **Sun Angle** — **45°**
- **Catalog**
  - **Star Positions** — **0.1”**

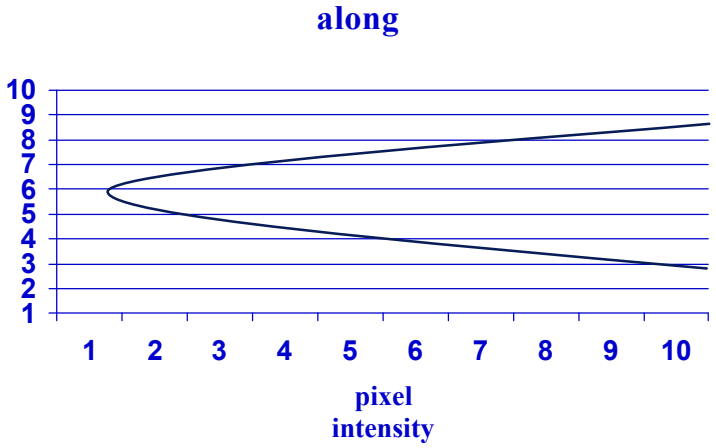
Derived Parameters

- **Integration Time** = 1.56 Seconds
- **Plate Scale** = 13.75 µ/Micron
  = 206 µ/Pixel or
  = 10^{-6} Radian/pixel
- **Rotation Rate** = 540"/Sec or 9°
- **Arcsec Subtended by CCD = 843.8 in Scan Direction**
- **PSF (FWHM)**
  - **Along Scan** ~1 Pixel
  - **Across Scan** ~ 4 Pixels
- **N e^- ~ 900,000 For 9th Magnitude Star Full Well » 100 Ke^-**

Accuracy of a Single Observation

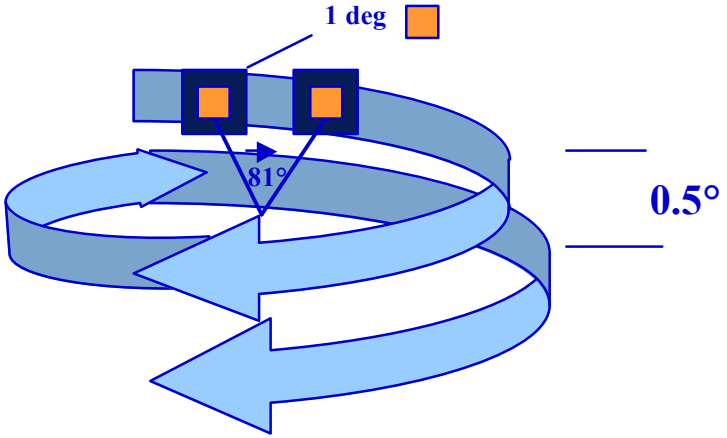






- Integration Time 1.56 Sec
- 10 Data Points/Star
- 10 Cross Scan Pixels Averaged for 10 Along Scan Pixels Data Points
- n Electrons @ 900,000 for 9th Magnitude
- Fit to PSF ~ 1/350 Pixel = 589 mas

Spiral/Global Solution



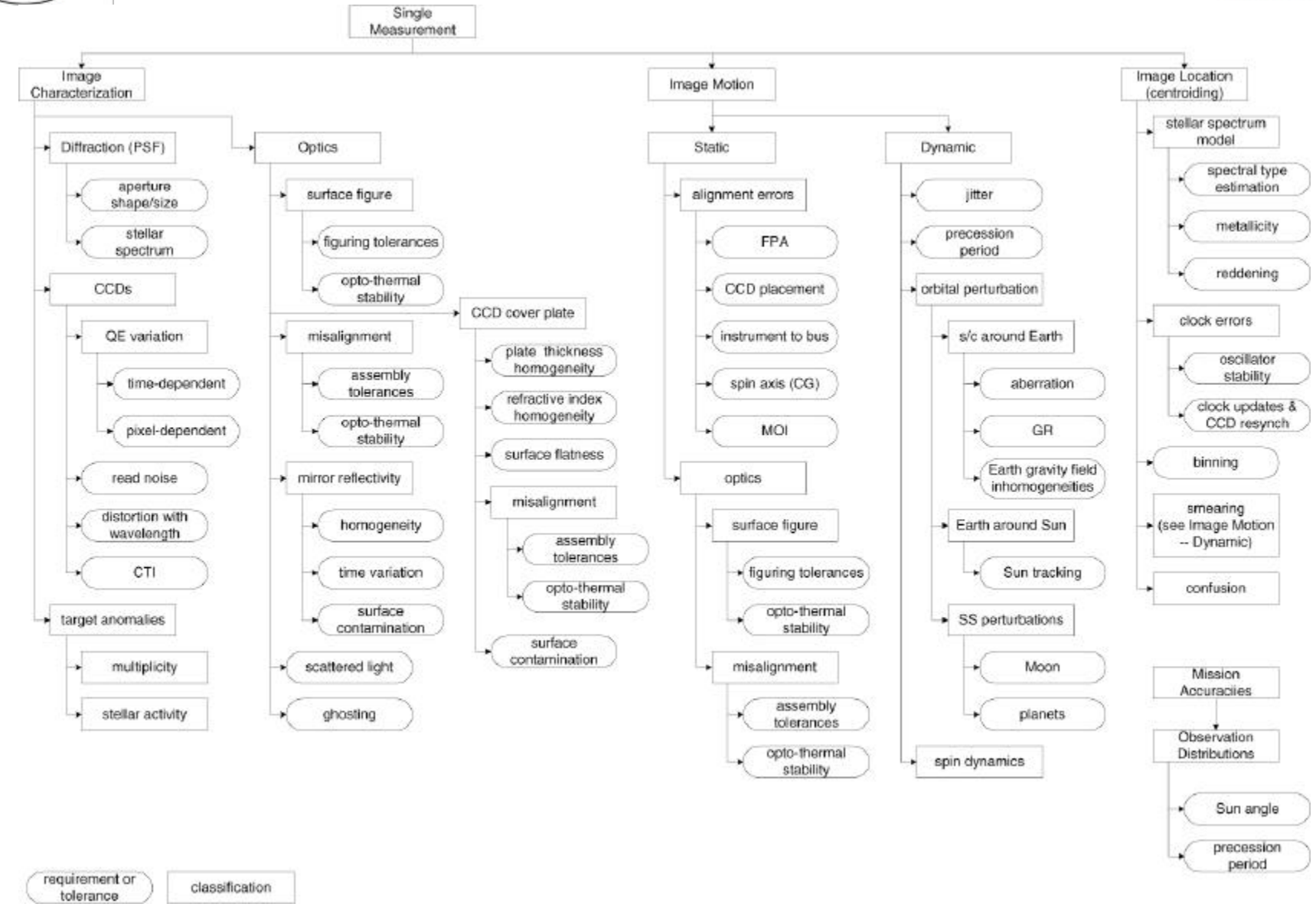
Stability										
	Along Scan					Cross Scan				
Rotation	Periods	0.2	1	10	100	Periods	0.2	1	10	100
Optics	Pixels	0.1	0.01	0.03	0.1	Pixels	1	0.1	0.3	1

Basic Angle	
Clock Stability	10^{-11}
S/C Orbit	1.0 cm/s

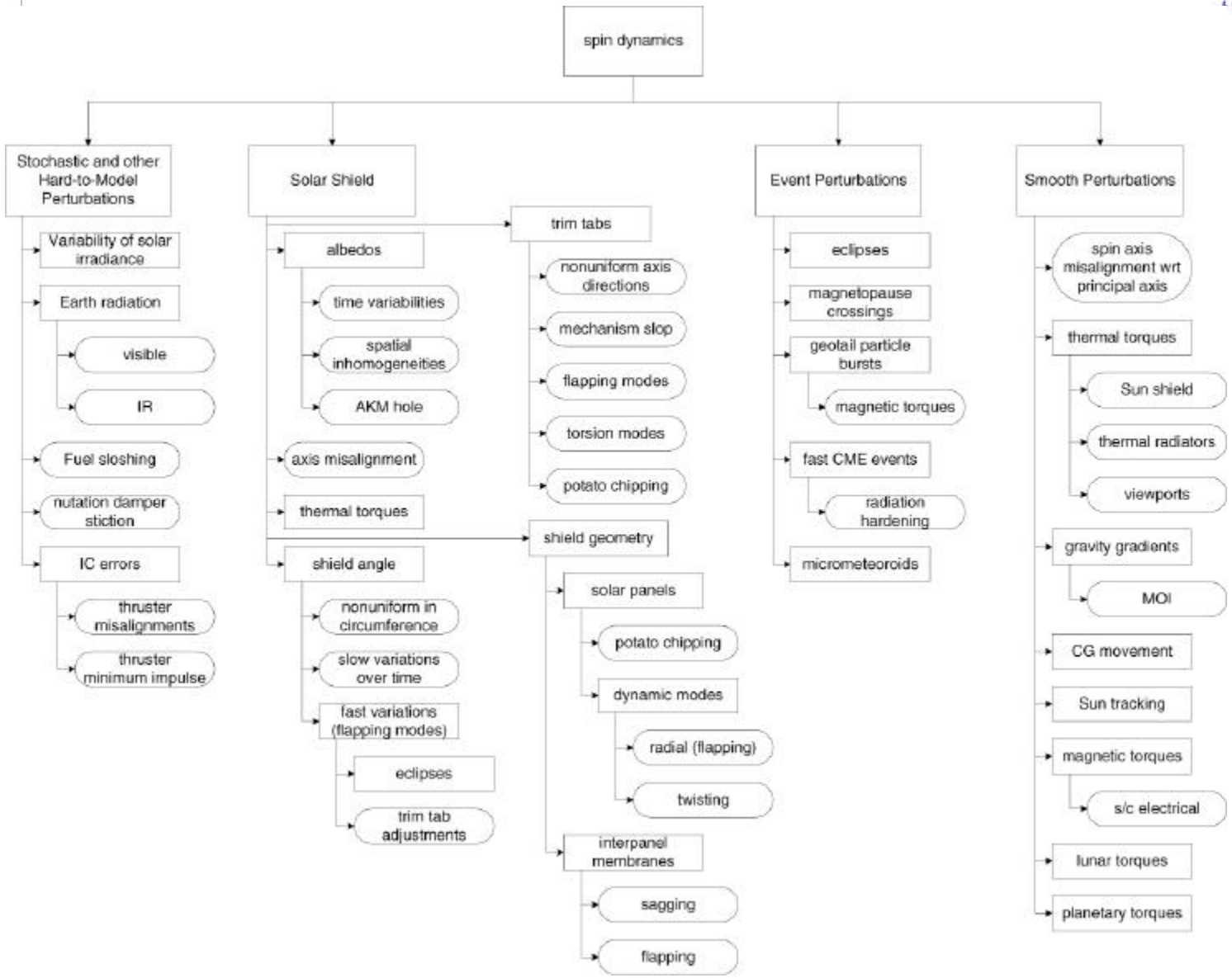
Error Budget (μas)

Source	a priori	a posteriori
Photon Statistics		
V=9	589	589
V=15	9328	9328
Single Observation Systematic Error of 105 mas Average to ~10 mas Over Mission		
CCD ® QE Variations	560	<10
Distortions f(l)	300	30
Charge Transfer Effects	800	80
Instrument Optics		
Geometry Changes	100	<10
Optical Distortion	2000	20
CCD Cover Plate	1	<1
S/C Rotation		
Variation of Solar Torque	10^6	<1
Earth Light in Ports	2500	24
Fuel Sloshing	<10	
PSF Centroiding		
Clock	10	<1
Stellar Spectrum	4000	50
S/C Velocity	10	1

FAME Error Budget Hierarchy (1 of 2)



FAME Error Budget Hierarchy (2 of 2)



Instrument Requirements

- Alignment of CCDs to Rotation Axis 5 μ rad
- *A priori* Star Position 0.1" or 0.5 pixel
- Precession 20^d @ 4.5 Pixels Max
- Optics Need Thermal Study
- S/C Velocity 1.0 cm/s
- Cross Scan 1/100 pixel
  - CCD Centroiding = 2 mas
- In Scan 1/350 pixel
  - TDI Errors
  - Clock Errors 10^{-11}
  - CCD Centroiding 1/350 pixel
  - Basic Angle 10 μas (0.015 nm)